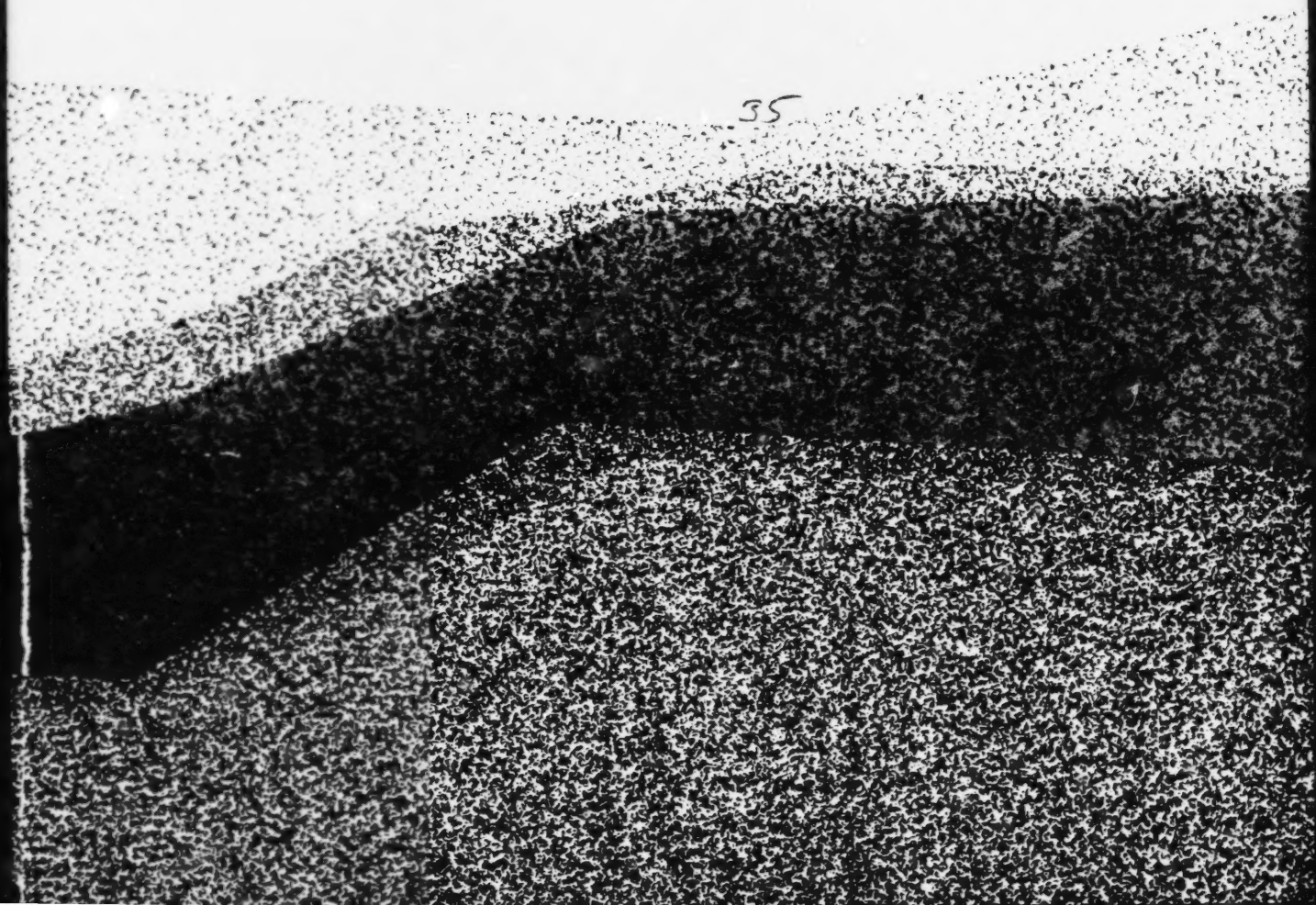
Centre for
Resource Studies

Queen's University
Kingston, Ontario

Dominant Government Firms in an Oligopolistic Industry: The Case of Saskatchewan Potash

FRANK FLATTERS
NANCY OLEWILER

Working Paper No. 29



DOMINANT GOVERNMENT FIRMS IN AN OLIGOPOLISTIC INDUSTRY: THE CASE OF SASKATCHEWAN POTASH

by

Frank Flatters and Nancy Olewiler

CENTRE FOR RESOURCE STUDIES
Working Paper No. 29
January 1984

Canadian Cataloguing in Publication Data

Flatters, Frank.
Dominant government firms in an oligopolistic industry: the case of Saskatchewan Potash

(Working paper, ISSN 0226-7616 / Centre for Resource Studies; 29)

ISBN 0-88757-038-0

1. Potash Corporation of Saskatchewan. 2. Potash industry and trade - Saskatchewan. I. Olewiler, Nancy D., 1948. II. Queen's University (Kingston, Ontario). Centre for Resource Studies. III. Title. IV. Series: Working paper (Queen's University (Kingston, Ontario). Centre for Resource Studies); 29.

HD9660.P7C34 1984 338.8'26223636 C84-098319-0

© Centre for Resource Studies, 1984
Queen's University
Kingston, Ontario

FOREWORD

This paper represents research sponsored by the Centre for Resource Studies aimed at improving knowledge of the Canadian mineral industry and the political and economic environment in which it operates. The Centre's working papers are offered for imformation and discussion, in an attempt to encourage feedback to the authors and additional research in mineral policy. Opinions presented are those of the authors, and do not necessarily represent the views of the Centre or its sponsors.

Margot J. Wojciechowski
Centre for Resource Studies

CONTENTS

Foreword / iii

Summary / vi

Resume / vii

1. Introduction / 1

2. A History of Government Policies / 3
   Saskatchewan's Role in World Potash Production / 3
   Constitutional Constraints / 4
   Evolution of the Saskatchewan Policies / 5
   Industry/Government Conflict / 7
   The Move to Provincial Ownership / 9

3. Output Strategies for PCS in an Oligopolistic Industry / 12
   Introduction / 12
   Nash Equilibrium and the Basic Model / 13
   Stackelberg Equilibrium / 17
   Joint-Project Equilibrium / 18
   Cartel Equilibria / 19

4. Saskatchewan Potash Production, 1975-80 / 22

5. Conclusions and Implications for Canadian Economic Union / 27

Bibliography / 28

The Authors / 29

Centre for Resource Studies / 30

CRS Publications / 31

TABLES

1. Saskatchewan, USSR and U.S. Share of World Potash Reserves and Production / 3

2. Oligopolistic Equilibria / 23

3. Market Share of Saskatchewan Producers, 1975-80 / 24

SUMMARY

Saskatchewan is the world's second largest producer of potash, the leading exporter, and holds by far the world's largest known reserves. In 1976, following unsuccessful attempts to regulate some aspects of the provincial potash industry and collect a higher share of the rents, the Government of Saskatchewan established a Crown corporation, the Potash Corporation of Saskatchewan (PCS), and began buying producing mines in the province. By the early 1980s, the provincial government was the largest single producer in the North American potash market.

Two key issues are addressed. Is it in PCS's interest to use its large share of the market to act as a dominant producer and increase its own profits at the expense of other potash producers? Is there an incentive for the private-sector producers in Saskatchewan to join in collusion with PCS and form a partial cartel? A theoretical model which analyzes different market equilibria in this oligopoly suggests answers to these questions. The model provides predictive information on output, prices, profits, and market shares for PCS, Saskatchewan private-sector producers, and the rest-of-the-world producers. On the basis of this theoretical analysis, it appears that few economic gains can be expected for Saskatchewan producers from participation in a cartel. In addition, if PCS is interested in maximizing the total rents from Saskatchewan potash (private plus public sector), it will not use its market power to act as a 'Stackelberg' leader.

Examination of the actual performance of PCS and other Saskatchewan producers over the period 1975-80 indicates that there has been no evidence of either collusive behaviour among Saskatchewan producers or Stackelberg leadership by PCS.

The findings suggest that this provincial Crown corporation will likely behave no differently from private-sector firms in the same export oriented industry, in spite of differing objectives. A provincial corporation may, however, divert some rents to the province from the federal government, and increase the total rents remaining in Canada due to the takeover of mines owned by foreign corporations.

RÉSUMÉ

La Saskatchewan est le deuxième producteur de potasse du monde, en est le principal exportateur et possède de loin les réserves connues les plus grandes du monde. En 1976, après avoir vainement essayé de réglementer quelques aspects de l'industrie de potasse provinciale et de recouvrer une part plus élevée des rentes, le gouvernement de la Saskatchewan a fondé une corporation de la Couronne, la Potash Corporation of Saskatchewan (PCS) et a commencé à acheter les mines productrices de la province. Au début des années 1980 le gouvernement provincial était seul le plus grand producteur sur le marché nord-amèricain de la potasse.

On traite de deux questions de première importance. La PCS a-t-elle intérêt à se prévaloir de sa grande part du marché pour agir à titre de producteur principal et augmenter ses propres bénéfices aux dépens des autres producteurs de potasse? Les producteurs du secteur privé de la Saskatchewan sont-ils encouragés à agir de connivence avec la PCS pour former un cartel partiel? Un modèle théorique analysant différents équilibres des marchés dans cet oligopole ébauche des réponses à ces questions. Le modèle fournit des informations donnant des prévisions dur le rendement, les prix, les bénéfices et les parts du marché retenus par la PCS, les producteurs du secteur privé de la Saskatchewan, et les producteurs du reste du monde. D'après cette analyse théorique, il apparaît que les producteurs de la Saskatchewan ne doivent pas s'attendre à de grands gains s'ils participent à un cartel. De plus, si la PCS s'intéresse à maximiser l'ensemble des rentes de la potasse de la Saskatchewan (secteurs public et privé), elle ne se servira pas de son pouvoir pour agir comme chef du marché, à la Stackelberg.

Selon une étude du rendement réel de la PCS et d'autres producteurs de la Saskatchewan pendant la période 1975 à 1980, il n'y a aucune indication ni de comportement collusoire parmi les producteurs de la Saskatchewan ni de direction à la Stackelberg chez la PCS.

Les conclusions suggèrent que, malgré ses objectifs différents, cette corporation de la Couronne se comportera en toute probabilité comme les firmes du secteur privé dans cette industrie orientée vers les explortations. Toutefois, une corporation provinciale peut détourner une part des rentes du gouvernement fédéral vers le gouvernement provincial, et augmenter l'ensemble des revenues restant au Canada par suite du rachat de mines appartenant à des corporations étrangères.

1. INTRODUCTION

The province of Saskatchewan is a relatively recent arrival in the world potash industry. Its large potash deposits remained undiscovered until 1943 and no significant production took place until 1962. Now Saskatchewan is the world's second largest producer (next to the USSR) and has the largest proven stocks of potash, sufficient to satisfy world demand for two or three thousand years at current prices and demand levels.[1] The Saskatchewan deposits were developed initially by the private sector. Then, for a variety of reasons, the government of Saskatchewan acquired a number of existing mines in the mid-1970s and now has direct control of 42.5 percent of Canadian capacity. This share is expected to grow through the 1980s.

Throughout the industry's history, the provincial (and to some extent the federal) government has used many policy tools in addition to ownership to regulate the industry, including various taxes and fees, quantitative restrictions on output, and investment. It is on the role of the provincial government that we focus in this paper. A variety of interesting economic issues is raised by government policies in this sector, including:

i the effects of the constitutional division of powers on the regulation of resource industries in a federal state;
ii the role of public ownership;
iii the effects of oligopolistic market structures on the evolution of a resource industry.

We will see how all of these issues are related in the history of the Saskatchewan potash industry, and examine the way in which the provincial power to regulate resources has come into conflict with federal powers of taxation and regulation of trade and commerce. These constitutional conflicts turn out to be the major reason that provincial ownership was chosen as the method of regulating the industry and acquiring a public share in the rents from potash in Saskatchewan. Most importantly, we examine the possible modes of behavior of a publicly-owned resource firm which controls a major share of output in a provincial oligopoly, which in turn is a principal actor in an international oligopoly. To what extent is the behaviour of such a dominant firm likely to be de-

1. Major resources of potash industry statistics are: Energy Mines and Resources Canada, Potash, Mineral Bulletin MR 156, Ottawa, 1976; and the annual surveys of potash in the Canadian Mining Journal and Canadian Mineral Surveys. Specific references are provided below.

structive of the Canadian common market and, more importantly, to impair the efficiency of resource allocation in the Canadian economy?

We begin with a general history of the evolution of government policies, interpreted in light of various possible policy goals and constraints, and then, in the following section, go on to develop a more formal model of optimal government behavior.

2. A HISTORY OF GOVERNMENT POLICIES

Saskatachewan's Role in World Potash Markets

As table 1 indicates, by any indicator of size, Saskatchewan plays a prominant role in world markets. Saskatchewan is the world's second largest producer, with about 26 percent of the world's total production and 46 percent of world reserves. It has been the world's largest exporter of potash for many years, and its reserves are by far the world's largest.

Saskatchewan's prominance is enhanced by two more factors. First, its reserves are of relatively high quality, which means that potash can be produced at lower cost than that of non-Saskatchewan competitors.[2] Second, since transportation costs are a major part of the delivered cost of potash, and Saskatchewan's major competition in the western U.S. market comes from the mines of New Mexico, this means that Canadian potash has a naturally protected market area which extends well into highest consumption areas of the U.S. market. Since the marginal cost of ocean shipping is also very small, Saskatchewan potash is able to penetrate many major off-shore markets such as those in South America and the Pacific Rim.

TABLE 1
SASKATCHEWAN, USSR AND U.S. SHARE OF WORLD POTASH RESERVES AND PRODUCTION
(Percent)

	Reserves	Production
Saskatchewan	46	26
USSR	31	29
USA	4	8

Sources: Data for 1979 (reserves) from Searles, J.P. 'Potash', Mineral Facts and Problems, U.S. Bureau of Mines, 1980, p. 710; data for 1980 (production) from G.S. Barry, 'Potash', Canadian Mining Journal, February 1982, p. 29.

2. The effects of higher ore quality on costs is attenuated to some extent by the higher capital costs of constructing the relatively deep mines required to gain access to the Saskatchewan deposits.

The international market in which Saskatchewan producers participate has experienced two cycles since Canadian production began in the early 1960s. The first downturn occurred at the end of the 1960s, just as all of Saskatchewan's new mines had or were about to come into production. This major slump manifested itself in a drastic reduction in potash prices and in considerable excess capacity among Canadian producers. The recovery began in late 1973, and the Saskatchewan industry subsequently experienced growing capacity utilization and continually rising prices. By the early 1980s, plans were in place for major expansions in the industry's production capacity over the next decade. However, by late 1981, the world recession, falling prices for land and agricultural products, and high interest rates, as well as a recovery of export production in the USSR, had conspired to produce another major slump in world potash markets. Since that time Saskatchewan producers once again have been faced with the twin spectres of falling prices and declining capacity utilization.

Constitutional Constraints

The regulatory environment of the potash industry in Canada is coloured very much by the nature of the federal state which vests various powers in the hands of either the provincial or federal governments or both. This division of powers has imposed restrictions on both levels of government and has led to considerable conflict between them. Under the British North America Act, which was in effect until 1982, the federal government had jurisdiction over matters of interprovincial and international trade and had the exclusive right to levy indirect taxes. On the other hand, the provinces had the authority to raise revenues from and regulate resources lying within their boundaries and could levy direct taxes (as could the federal government). Neither government could levy taxes on the other level of government or its agencies.

It is not difficult to imagine both the possibilities for conflict between provincial and federal governments and the constraints on the ways in which the provinces might exercise their powers due to this constitutional environment. One of the major issues in the discussion of the division of economic powers in the new constitution centered on the conflict between provincial powers over resources and the federal powers over trade and commerce and taxation. The primary commodities boom of the 1970s produced massive regional differences in resource rents and in the fiscal positions of various provincial governments and the federal

government.[3] The political and constitutional conflicts have threatened to destroy the Canadian common market. Unfortunately, neither the courts nor the new constitution have been able to resolve the underlying problems. Faced with constitutional ambiguity, the Supreme Court of Canada has tended to muddy the waters further by making decisions based on irrelevant and incorrect economic assumptions, while the constitution makers refused to deal squarely with the issues.[4] We shall see that constitutional considerations have played a large role in the design of provincial potash policies in Saskatchewan.

Evolution of the Saskatchewan Policies

We now attempt to trace in more detail the history of Saskatchewan government policies towards the potash industry, and in particular to describe the underlying policy goals.[5] The first Saskatchewan potash mine, with an estimated annual capacity of 1.2 million tons (K_2O), was opened by International Minerals and Chemical Corporation (Canada) Ltd. (IMCC) in 1962. By 1970 nine more mines had been opened, and the Saskatchewan industry's annual capacity was estimated to be 7.6 million tons (K_2O) by the end of the decade.[6] The province's ten mines were

---

3. See Economic Council of Canada, Financing Confederation, Ottawa, 1982, chapter 4 for illustration of the magnitude of some of these effects.
4. For a good analysis of the two important Supreme Court decisions with respect to resource management, and of the new constitutional arrangements in this regard, see the following two papers by William D. Moull: 'Natural Resources: The Other Crisis in Canadian Federation', Osgood Hall Law Journal, 18 March 1980, pp. 2-48; 'Section 92A of the Constitution Act, 1867 - Some Thoughts and Reflections', mimeo, Feb. 18, 1982. See also John D. Whyte, 'A Constitutional Perspective on Federal-Provincial Sharing of Revenues from Natural Resources', in C.E. McLure, Jr. and Peter Mieszkowski, (eds.) Fiscal Federalism and the Taxation of Natural Resources, (Lexington, Mass.: D.C. Heath & Co., 1983).
5. Other surveys of aspects of the history of the Saskatchewan potash industry can be found in David L. Anderson, The Role of Mineral Taxation in Industry-Government Conflict, (Kingston: Centre for Resource Studies, 1981); Jeanne Kirk Laux and Maureen Appel Molot, 'The Potash Corporation of Saskatchewan', in Allan Tupper and G. Bruce Doern (eds.), Public Corporations and Public Policy in Canada, (Montreal: The Institute for Research on Public Policy, 1981); and John Richards and Larry Pratt, Prairie Capitalism: Power and Influence in the New West (Toronto: McClelland and Stewart, 1979). Our own survey is based largely on Anderson, Moull, various Government of Saskatchewan publications, and the industry surveys by Energy, Mines and Resources, Canada.
6. Energy, Mines and Resoruces Canada, Potash, p. 8, table 4.

operated by nine companies, of which two (Noranda and Cominco) were Canadian, five were U.S.-controlled, one was British and South African, and one was Franco-German with French government interests.[7]

The development of the industry was encouraged by a guaranteed schedule of low provincial royalty payments. This guarantee was provided in 1962 and was promised to extend to 1974 for all but the two pioneers in the industry (IMCC and the Potash Corporation of America, PCA), whose low royalty schedules were guaranteed until 1981. Further encouragement of speedy development was provided in 1964 by an extension of the low royalty guarantee to all mines whose construction had begun before 1 October 1967.

This marked the end of what might be called the initial expansionary phase of Saskatchewan government policy. The primary policy goal seems simply to have been to establish the industry in the province. To the extent that provincial government revenues were a concern, the government must have had a rather long-run view. Overall public policy could be described as either laissez-faire or tending to encourage expansion in the industry. In any case, the government showed a willingness to be accommodating to the private developers of the province's potash resources.

By the end of the 1960s, however, with the downturn in North American and world potash markets, the industry and the government came under new pressures. The Canadian industry now made up a significant share of world production and the growth in its capacity had given it the potential to have a major impact on market prices. Uncoordinated behaviour by Canadian producers would put downward pressure on potash prices, while collusion to withhold potential supplies from market would help to keep prices up. There clearly were gains to be had from monopolistic behaviour in Saskatchewan. The problem was to find a way to coordinate the independent oligopolistic behaviour of the nine Saskatchewan producers. At the same time that the slump in potash prices was drawing attention to the advantages of cooperative behaviour by Saskatchewan producers, U.S. governments were coming under pressure from producers in New Mexico to restrict Canadian potash imports. The problem was that the low-cost Canadian product was undercutting that of the higher-cost New Mexican mines.[8] In late 1969, in order to forestall anti-dumping proceedings against Canadian potash, Saskatchewan government officials met with their New Mexican counterparts to propose a scheme to limit Saskatchewan exports to the USA.

---

7. Ibid.
8. We have found no mention at this time of corresponding pressures from U.S. potash users to ensure adequate supplies of the cheaper Canadian potash.

The result of these pressures was the introduction, at the end of 1969, of prorationing of Saskatchewan production. Under the new provincial Potash Conservation Regulations, mines would be issued production licenses based on three factors:

i 40 percent of the production capacity of each mine;
ii market demand for Saskatchewan potash;
iii working stock and reserve requirements.

A floor price was also established. Both the Saskatchewan producers and the government of New Mexico were apparently happy with this arrangement. For New Mexican producers the net effect was that, while Canadian mines were producing at less than 50 percent of capacity, those in New Mexico were at about 90 percent. The Saskatchewan producers benefited by having the provincial government act as the coordinator and enforcer of cooperative behaviour. The province still displayed little apparent interest in the size of the public revenues that would accrue from the industry, at least in the short run.

It is not clear whether it was the threat of anti-dumping actions from the USA or the desire to rescue the Saskatchewan industry from plummetting prices and profits which was more important in motivating the provincial government. However, both of these forces operated in the same general direction and their effect was to involve the government in behaviour aimed at enhancing the monopoly rents available to Saskatchewan producers. While measures that increased the price of potash to Canadian consumers entailed some efficiency cost on the consumption side, this was dwarfed by the gains on the production side since such a large portion of Canadian production is exported.[9] The only difficulty from a Canadian viewpoint was that, since most of the mines were foreign owned, a large share of the producers' gains did not accure to Canadians. In any case, the producers could find little to disagree with in provincial government policies.

Industry/Government Conflict

The first indication of possible conflict between the goals of government and of the industry came in June of 1972 when the government tightened up the prorationing regulations and introduced a prorationing fee of 60 cents per short ton. The main effect of the new regulations was to

9. In 1981, for instance, less than 4 percent of Canadian production was sold domestically. See G.S. Barry, 'Potash', Canadian Mining Journal, February 1982, p. 128, table 1.

make it impossible for any individual mine to exceed its production quota, regardless of the market opportunities available. The only company that this affected was Central Canada Potash (CCP) which had a long-term arrangment to sell amounts greater than its production quota to CF Industries of Chicago (which owned 49 percent of CCP). To fulfill this contractual arrangement, CCP would have to buy from other producers. Aside from CCP, the rest of the producers did not appear to be unduly disturbed by the government's output restrictions; after all, the regulations did not differ substantially from those that might have been self-imposed through cooperative behaviour. The prorationing fee, however, was another matter. Although it was relatively small, it indicated that the government was interested in procuring a share of the potash rents, which it was helping to secure, for the provincial treasury. While the government was still interested in maximizing the profits of the Saskatchewan industry, it was now indicating a desire to increase its own share of these profits.

A complex series of legal and policy actions was set in motion in July 1972, when CCP challenged its prorationing allocation. In December CCP launched another action, challenging the constitutionality of the provincial prorationing provisions in the Potash Conservation Regulations. In November 1973 CCP was joined by the federal government as a co-plaintiff. Meanwhile, in October 1973, as potash prices and hence profits began to recover, Saskatchewan doubled the prorationing fee to $1.20 per short ton. However, in the face of the uncertain legal environment and the increasingly confrontational relationship with private firms, the Saskatchewan government had to explore alternative policy tools for accomplishing its twin goals of maximizing the economic rents from Saskatchewan potash and ensuring that a significant share went to the provincial treasury.

Several new policies were introduced in 1974. The provincial government announced its intention to levy a new potash reserve tax. This was implemented late in the year, together with a policy requiring government participation in new mines. For this latter purpose the provincially-owned Potash Corporation of Saskatchewan (PCS) was set up in 1975. As potash markets recovered in 1974, the government removed both the production quotas and the price of floor provisions contained in the Potash Conservation Regulations.

Late in the year, adding further to the conflict over the sharing of rents from the potash industry, the federal government announced that it would no longer allow mining companies to deduct provincial royalties as a cost in calculating taxable corporate income. This federal move was part of a larger federal-provincial conflict over revenue sharing in all resource industries, but particularly oil. The nontaxable status of pro-

vincial Crown corporations under the BNA Act suggested a way for the provinces to nullify the effects of this federal policy.

Several court actions in 1975 imposed further constraints and doubts on the ability of the province to regulate the potash industry. First, in May 1975, the Saskatchewan Court of Queen's Bench ruled that the provincial prorationing policy was beyond the powers of the provincial government. Then, later in the year, two new challenges to provincial authority were launched. In June all the companies (except CCP) attached the legality of the potash reserve tax and then in October the firms questioned the constitutionality of prorationing fees.

The Move to Provincial Ownership

The province's ability to use traditional regulatory instruments was being seriously eroded. In particular, the power to regulate output through a system of quotas and the ability to regulate and raise revenues through taxation were becoming more constrained. In light of this, as well as the fact that provincial governments and their agencies are not taxable by the federal government, the province's next move was quite predictable. In November 1975 the newly re-elected government announced in the Throne Speech its intention to acquire control over the potash industry through direct ownership.

The announced target was to purchase about 50 percent of existing mining capacity. This, together with the (so far) undisputed power to control investment in new mining capacity would give the province direct access to rents generated in the potash industry. More importantly, as the dominant producer in this oligopolistic market, the provincial firm might be able to use its market power to influence the behaviour of the other firms and induce the Saskatchewan producers to behave collectively in a manner closer to that of a rent-maximizing cartel. The behaviour of the public corporation might be a substitute for the power to regulate the industry in a more direct manner. The net benefits to the province would clearly depend on the relationship between the purchase price of the mines and the actual future rents generated from these mines. The fact that the 'fair market value' was to be determined inclusive of the effects of the reserve tax certainly worked in the government's favour in this respect. In January 1976 the Potash Development Act was passed and in April the Potash Corporation of Saskatchewan Act was proclaimed.

From this point until the present, the plot has unfolded with very few surprises. In August 1976, after two months of negotiations, PCS completed its first purchase, the Duval mine. Between then and the end of 1978 it also had acquired the mines of Hudson Bay Mining and Smelt-

ing, Alwinsal Potash, and 60 percent of APM Operators' mine, giving it about 40 percent of Saskatchewan's capacity. The total cost of these acquisitions was $532 million. The PCS strategy for the 1980s has shifted from the purchase of existing mines to expansion of its own mines, development of new mines, and joint expansion ventures with existing firms. There has been some expansion begun or planned by the private sector, but not at the same scale as PCS. By the end of the 1980s the PCS share of the Saskatchewan capacity could be higher than 55 percent.

In late 1979, after some unfavourable court judgements,[10] the province signed a five-year Resource Payment Agreement with all the private companies. This agreement, which resulted in substantially reduced provincial tax burdens, was recognized as a settlement of all outstanding legal proceedings between the province and the private sector.

Since the early 1980s, then, the provincial government, through PCS, has controlled the dominant firm in a controlling segment of the North American and world potash markets.[11] In addition, it collects tax revenue from the private firms, and can regulate capacity expansion in the province. The election of a Conservative government in 1982 has cast some doubt on the earlier plans of the province with respect to PCS. For instance, the new government's first Minister of Mines suggested that all additions to potash mining capacity would be made by the private sector, rather than PCS.

This uncertainty makes it even more important to understand the powers and likely behavior of PCS in the provincial and world potash markets. In this paper we develop some models of oligopolistic markets in order to identify how PCS behaviour might affect provincial revenues and the behaviour of the rest of the industry. There are three major

---

10. In particular, on 3 October 1978, the Supreme Court of Canada ruled provincial prorationing ultra vires. In part the judgement read: 'it is, of course, true that production controls and conservation measures with respect to natural resources in a province are ordinarily matters within provincial legislative authority. The situation may be different, however, where a Province establishes a marketing scheme with price fixing as its central feature. Indeed, it has been held that provincial legislation authority does not extend to the control or regulation of the marketing of provincial products, whether minerals or natural resources, in interprovincial or export trade'. See G.S. Barry, 'Potash', Canadian Mining Journal, February 1979.
11. A further possible constraint on the potential exercise of monopoly power in the Saskatchewan potash industry arose in 1976 when the USA brought an indictment against six potash companies and their subsidiaries for conspiracy in restraint of trade by restrictive sales of potash and price fixing. Pending an out-of-court settlement, the case was dropped in 1977. A.F. Killin, 'Potash' in Canadian Mineral Surveys, 1977, pp. 70-71.

sets of actors: foreign producers, private producers in Saskatchewan, and PCS. We analyze industry output, prices, and profits under various assumptions about the existence and behaviour of PCS.

3. OUTPUT STRATEGIES FOR PCS IN AN OLIGOPOLISTIC INDUSTRY

Introduction

We do not know how a government-managed dominant producer will behave in an oligopolistic industry. However, we can sketch some of the possible strategic options open to PCS, given the oligopolistic structure of the industry and the legal, political, and technological constraints PCS faces. Our objective is to examine some plausible strategies using a simple model of the potash industry. Our approach is somewhat unusual in that we do not impose, a priori, an equilibrium concept on the industry. Rather, we define and discuss alternative equilibria in an attempt to discover which one (or ones) is most compatible with PCS's powers, constraints, and possible objectives. As will be seen, one type of equilibrium appears to dominate the others, at least over the short term.

We focus solely on output as the choice variable for PCS. This is because quantity-setting behaviour is more appropriate than price setting in our model and, as noted in chapter 2, the Saskatchewan government is limited constitutionally in its use of the more traditional policy instruments of taxation and regulation to affect industry behaviour and collect rents.

The outline of this chapter is as follows. First we develop a model for the North American potash industry. We restrict ourselves to North America because the type of oligopolistic behaviour we describe is more representative of this market than the offshore (non-North American) markets. Canpotex, a Canadian export 'cartel', is responsible for all sales of Saskatchewan potash outside of North America. Each potash producer including PCS has only one vote when making any export sales agreement, so on the surface a dominant-firm model would not be a good characterization of this part of the market. PCS did withdraw from Canpotex at one point, but rejoined when the Progressive Conservatives won the Saskatchewan provincial election in 1982. It is not clear to us exactly how Canpotex operates, so we confine our analysis to the market in which no explicit collusion occurs.

Given the basic structure of the model, we then examine five cases which reflect different oligopoly equilibria. They are:

i Nash-Cournot (non-cooperative) equilibrium;[12]

ii Stackelberg equilibrium, with PCS as the Stackelberg leader;[13]

iii a Stackelberg equilibrium where PCS is concerned with maximizing the profits of the private-sector Saskatchewan producers as well as its own;

iv a 'cartel' consisting of PCS and Saskatchewan private-sector producers acting as Stackelberg leaders;

v a cartel of PCS and Saskatchewan producers behaving as Nash-Cournot firms.

From these equilibria, we derive predictions about output, prices, profits, and the market shares of each participant. We then attempt to determine which equilibrium concept is most compatible with actual sales of potash in North America over the period 1975-80. Our evidence suggests that one kind of equilibrium characterizes past observations and will likely continue to dominate the others, regardless of PCS's precise objectives.

Nash Equilibrium and the Basic Model

We assume that the North American potash industry is an oligopoly in which each firm produces a homogeneous product and faces a downward

---

12. The Nash-Cournot or Nash equilibrium (non-cooperative equilibrium) is one in which each firm determines its output level based on the assumption that all other firms' outputs are given and will not change. Firms thus ignore any possible interdependence between each other in determining production levels. A non-cooperative equilibrium then exists when, for each firm, the output chosen maximizes profits; no change in output will increase any one firm's profits. That is, an equilibrium occurs when the assumed behaviour is actual behaviour. See a standard microeconomics text for illustrations of the Nash-Cournot equilibrium; e.g. E. Mansfield, Microeconomics, Theory and Applications, 3rd edition, New York: W.W. Norton and Company, 1979.

13. The Stackelberg, or leader-follower, equilibrium assumes that one firm has sufficient 'market power' to act as a leader, while the other firms act passively as followers. The leader chooses a profit-maximizing output level assuming that the followers will take the leader's output as given when maximizing their profits. The followers thus believe that the leader's output will not be affected by their decisions. An equilibrium then consists of output levels chosen such that these beliefs are realized and profits are maximized. The Stackelberg equilibrium will tend to increase the profits of the leader and depress the profits of the followers relative to the Nash-Cournot case, as will be seen.

sloping demand curve which is dependent on aggregate industry output. An oligopolistic market structure seems appropriate, given the small number of firms in the industry. Prior to the emergence of PCS, no one firm controlled a substantial portion of the productive capacity of the industry and there is little evidence of consistent price leadership by any one firm.[14] We also observe simultaneous extraction from both low-cost and high-cost producers, an occurrence which can be consistent with oligopoly in a resource industry, but generally not with perfect competition.[15] We therefore use a Nash or non-cooperative oligopoly solution as a reference equilibrium in our analysis. Possible PCS strategies which yield different equilibria are then contrasted with the Nash solution.

Our model is static. While we recognize the limitations of a static model, it enables us to focus on different equilibria in a tractable fashion. (We plan to solve a dynamic version of the model in the future, using numerical simulation.) The static model is in fact a reasonable approximation of behaviour, because of the size of Saskatchewan's potash reserves. The stock of known reserves is so large (2 to 3 thousand years' supply) that the effective shadow price on ore in the ground is zero. Rent due to exhaustibility of the resource (but not differential quality) will be zero for many years in Saskatchewan (but not necessarily for other producers).

We assume there are three 'firms' in the industry. Each represents an important type of producer and reflects different cost conditions. Let firm g be PCS; s, the Saskatchewan private-sector producers (hereafter referred to as S producers), and r the rest-of-the-world producers which supply the North American markets (hereafter referred to as ROW).[16] The three-firm model is used for computational ease, but does characterize the important features of the industry. Our specific results would change as we add firms but their qualitative features would be similar.

---

14. There are some specific arrangements in the industry where individual firms do not act like pure Nash competitors. For example, Central Canada Potash (owned by Noranda) has most of its output directly committed to a farmer's cooperative in the USA, C.F. Industries (as noted in chapter 2).
15. See T.R. Lewis and R. Schmalensee, on 'Oligopolistic Markets for Nonrenewable Resources', Quarterly Journal of Economics, XCV, 1980, pp. 475-491.
16. In practice there are relatively few ROW suppliers. The principal producers are from New Mexico, Germany, Israel, and some supplies come to North America from the Soviet Union.

In the non-cooperative equilibrium, each firm is assumed to maximize its profits by choosing a level of output, q_i, where i = g,s,r. The level of output chosen by each firm depends on its costs and the market demand curve D(P), which is assumed to be linear. Price, P, is dependent on the total industry output, Q, such that

$$P = a - bQ \qquad \text{where } Q = \sum_i q_i. \tag{1}$$

Each firm has zero fixed costs and constant average and marginal costs of extraction, c_i. We assume that PCS and S producers have identical costs which are less than the costs faced by the ROW producers. These assumptions are not arbitrary but reflect actual cost conditions. PCS operates four different mines which range from having one of the lowest average costs in the province to one of the highest. Private-sector Saskatchewan firms taken together (as this model assumes) have approximately the same range in their extraction costs. Our survey of the industry also suggests that, due to their large reserves and high grade, most Saskatchewan mines have lower unit costs of extraction than non-Saskatchewan producers.

As previously mentioned, we assume that all firms sell a homogeneous product. This assumption is also consistent with observation. The dominant North American potash product is potassium muriate (KC1) which represents 95 percent of the potash consumed in the USA.[17] There are differences in the potash (K_20) content of the muriate due to the type and quality of the ore, but not in the final product. Saskatchewan's K_20 content (referred to as K_20 equivalent) is generally over 60 percent, while that of suppliers outside North America averages 40 percent.

The non-cooperative equilibrium for the oligopoly is then derived from the simultaneous solution of the three firms' reaction functions, where the reaction functions are obtained in the usual way from each firm's first-order conditions for a maximization of its profits.

Let $Q_{-i} = \sum_{j \neq i} q_j$; then, profit maximization requires each firm to equate marginal revenue (MR) to marginal cost (MC), where

$$MR_i = a - 2bq_i - bQ_{-i} \tag{2}$$

$$MC_i = c_i$$

Equating $MR_i = MC_i$ and solving for q_i, we obtain the ith firm's reaction function, i.e. its profit-maximizing response to the other firms' output levels which maximize their profits,

17. U.S. Bureau of Mines, Mineral Facts and Problems, 1980.

$$q_i = \frac{a-c_i}{2b} - \frac{1}{2} Q_{-i} \qquad (3)$$

For i = g,s,r, the Nash equilibrium must then have q_g, q_s, q_r chosen simultaneously, such that equations 4 are satisfied.

$$\begin{aligned} q_g + \tfrac{1}{2} q_s + \tfrac{1}{2} q_r &= \frac{a-c_g}{2b} \\ \tfrac{1}{2} q_g + q_s + \tfrac{1}{2} q_r &= \frac{a-c_s}{2b} \\ \tfrac{1}{2} q_g + \tfrac{1}{2} q_s + q_r &= \frac{a-c_r}{2b} \end{aligned} \qquad (4)$$

With our assumption that $c_g = c_s$, the solution of equations 4 is simplified. Let $c_g = c_s = c_L$, (where c_L represents low-cost producers). It is then clear that q_g must equal q_s. We can then collapse the three reaction functions into two, and solve for the output from either PCS or S, which we denote q_L, and ROW output, q_r. We therefore solve

$$\begin{aligned} \tfrac{3}{2} q_L + \tfrac{1}{2} q_r &= \frac{a-c_L}{2b} \\ q_L + q_r &= \frac{a-c_r}{2b} \,. \end{aligned} \qquad (5)$$

We find that

$$\begin{aligned} q_L &= \frac{a + c_r - 2c_L}{4b} \\ q_r &= \frac{a - 3c_r + 2c_L}{cb} \,. \end{aligned} \qquad (6)$$

Without loss of generality and for analytical ease in comparing the Nash solution to the other equilibria, let $c_L = 0$, $b = .5$, and denote $c_r = c$. Equations 6 then become

$$\begin{aligned} q_L &= \frac{a + c}{2} \\ q_r &= \frac{a - 3c}{2} \end{aligned} \qquad (7)$$

Summing the output, $2q_L + q_r$, we get $Q = 3/2\ a - 1/2c$, which, when substituted into the demand curve, yields the equilibrium price $P = 1/4\ (a-c)$.

Stackelberg Equilibrium

Suppose now that PCS can act as a Stackelberg leader. Because it controls a large percentage of North American sales and 45 percent of total reserves, it decides to try to maximize its own profits independently of other producers by announcing its output and forcing the other firms to take q_g as given. Firms S and ROW continue to act as Nash oligopolists.

The Stackelberg equilibrium then consists of PCS's profit-maximizing output q^*_g, and the other firms' reaction functions which depend on q_g. Using the same assumptions as for the Nash equilibrium, we obtain the reaction functions

$$q_s = \frac{2}{3}(a+c) - \frac{1}{2} q_g$$

and (8)

$$q_r = \frac{2}{3} a - \frac{4}{3} c - \frac{1}{3} q_g$$

PCS then maximizes its profits Π_g, given the demand curve dependent on its output and the q_s, q_r from equation 8.

$$\Pi_g = q_g \left\{ a - \frac{1}{2} \left[q_g + \frac{2}{3}(a+c) - \frac{1}{3} q_g + \frac{2}{3} a - \frac{4}{3} c - \frac{1}{3} q_g \right] \right\} \quad (9)$$

$$= \frac{1}{3}(a+c) q_g - \frac{1}{6} q_g^2.$$

Then

$$\frac{d\Pi_g}{dq_g} = \frac{1}{3}(a+c) - \frac{1}{3} q_g = 0 \quad (10)$$

which can be solved for $q_g = a+c$, PCS's Stackelberg output. The outputs for s and r are then

$$q_s = \frac{2}{3}(a+c) - \frac{1}{3}(a+c) = \frac{1}{3}(a+c)$$

$$q_r = \frac{2}{3} a - \frac{4}{3} c - \frac{1}{3}(a+c) = \frac{1}{3} a - \frac{5}{3} c. \quad (11)$$

The market price is $P = \frac{1}{6}(a+c)$.

Thus we can see that, if PCS acts as a Stackelberg leader while the other firms are followers, PCS will double its output and hence greatly increase its market share relative to the Nash case. This behaviour reduces the output and market shares of the other firms, but total industry output rises and the market price falls. The profits of PCS rise while those of other firms decline substantially.

Joint-Profit Equilibrium

In this case, we assume that PCS's objective function is more broadly defined than it was in the case of the Stackelberg equilibrium, and includes the profits of S producers. However, it still acts as a Stackelberg leader, and S and ROW producers are still non-cooperative followers. The rationale for this case is that, as a government firm, PCS may be interested in total Saskatchewan profits or rents, not just its own. PCS may seek to maximize private sector rents for a number of reasons. For example, it may want to maximize the provincial government's tax revenues from mining (based as noted previously on 'direct' profits taxation), or to contribute to provincial employment, etc.

Given this new objective, PCS's profits can now be defined as $\hat{\Pi} = \Pi g + \gamma \Pi s$, where γ is the weight PCS attaches to the profits of the private sector. The weight can be thought of as the government's share of profits, say through taxation, or the degree to which it 'cares' about the S producers' profits. We initially set $\gamma = 1$ to obtain the results for complete joint-profit maximization, then discuss the modifications to our results with $\gamma < 1$.

As in the previous case, we maximize PCS's profits $\hat{\Pi}$, given the reaction function q_g and q_r. That is,

$$\hat{\Pi} = (q_g + \gamma q_s)(a - bQ) \qquad (12)$$

$$= \frac{2}{3}\left[\frac{1}{3}(a+c)^2 + \frac{1}{6}(a+c)\,q_g - \frac{1}{6}q_g^2\right]$$

Then $\frac{d\hat{\Pi}}{d\,q_g} = 1/6(a+c) - 1/3\,q_g = 0$ and solving this yields $\hat{q}_g = 1/2$ $(a+c)$. The output for PCS is thus identical to its Nash output. Given q_g, then q_s, q_r, and P are also identical to their Nash solutions. Although this particular result (the equivalence of the Nash and joint-profit Stackelberg cases) is dependent on the three-firm assumption, it is interesting and perhaps somewhat surprising (at least to us).

If we have $\gamma < 1$, the optimal output for PCS rises while that of the S producers falls (as does the output for the ROW producers). For example, with

	$\gamma = .5$	$\gamma = .75$	(13)
$q_g =$	$\frac{4}{5}(a+c)$	$\frac{2}{3}(a+c)$	
$q_g =$	$\frac{2}{5}(a+c)$	$\frac{4}{9}(a+c)$	
q_g	$\frac{2}{5}a - \frac{8}{5}c$	$\frac{4}{9}a - \frac{14}{9}c$	

The joint-profit equilibrium with $\gamma < 1$ thus lies between the pure Nash and Stackelberg solutions. If the provincial government through PCS is interested in some degree of joint-profit maximization, it may view $\gamma<1$ simply because it does not tax the industry at anywhere near 100 percent of its economic profits, and because some of the private-sector producers operating in Saskatchewan are controlled by foreign interests.

Cartel Equilibria

Because of the size of the combined reserves and productive capacity of PCS plus S producers, an obvious question is whether Saskatchewan producers have any incentive to cooperate with each other to increase their share of the market at the expense of the ROW producers. That is, are there any gains to partial cartelization of the potash industry in North America? We consider two cases.

In the first, which we denote the 'Stackelberg cartel', PCS and S firms cooperate in setting their combined output. They act as a Stackelberg leader while the ROW producers are still followers. Let $\tilde{q} = q_g + q_s$; then the ROW reaction function becomes $q_r = (a-c) - 1/2\tilde{q}$. The cartel maximizes its profits denoted $\tilde{\Pi}$ subject to q_r's reaction function, so

$$\tilde{\Pi} = \tilde{q}\left[a - \frac{1}{4}\tilde{q} - \frac{1}{2}(a-c)\right] \qquad (14)$$

$$= \frac{1}{2}(a+c)\tilde{q} - \frac{1}{4}\tilde{q}^2.$$

Then

$$\frac{d\tilde{\Pi}}{d\tilde{q}} = \frac{1}{2}(a+c) - \frac{1}{2}\tilde{q} = 0 \text{ and therefore } \tilde{q} = (a+c)$$

With PCS and S producers equally dividing q, each will produce 1/2(a+c), and again we have the Nash solution for each firm. Alternatively, total output is the same as in the single-leader Stackelberg case but it must be divided equally among cartel members. We then get the well-known result that increasing the number of firms participating in the cartel decreases the output and profits for each. Under this equilibrium concept, there are thus no gains to cooperation and partial cartelization compared to the non-cooperative equilibrium. S producers would however produce more and obtain higher profits relative to the Stackelberg equilibrium.

Because there are no gains to forming this sort of cartel relative to the Nash equilibrium, and many legal and political reasons why it would be undesirable, we do not think it is a likely candidate for PCS and S producer behaviour except under some particular circumstances which are discussed in chapter 4.

There is however, a second cartel equilibrium that might be a more viable arrangment. We call this the 'Nash cartel'. Again, PCS and S producers cooperate in choosing q, where we let $\bar{q} = q_g + q_s$. In this case the cartel does not announce its output plans prior to that of the ROW. Instead, it behaves like a Nash oligopolist. The Nash equilibrium for what is now a duopoly are the output levels $\bar{q}$ and q_r which satisfy the following reaction functions:

$$\bar{q} = a - \frac{1}{2} q_r$$

$$q_r = (a-c) - \frac{1}{2} q_r \qquad (15)$$

Solving equation 14, we obtain

$$\bar{q} = 2/3\ (a+c),$$

and

$$q_r = 2/3\ a - 4/3\ c.$$

With these output levels, the equilibrium price is $P = 1/3\ (a+c)$.

The Nash cartel equilibrium has some interesting implications for short-term versus long-term objectives of PCS. The equilibrium is somewhat similar to that obtained in the familiar OPEC cartel models.[18] The

18. See for example: R.S. Pindyck, 'Gains to Producers from the Cartelization of Exhaustible Resources', Review of Economics and Statistics, 60, 1978, pp. 238-251; S.W. Salant, 'Exhaustible Resources and Industrial Structure: A Nash-Cournot Approach to the World Oil Market', Journal of Political Economy, 84, 1976, pp. 1079-1093.

potash cartel decreases its output compared to all other equilibria considered, while the output of the ROW producers rises. The market price rises, increasing the profits of the ROW producers, and the profits of the cartel decline slightly. The ROW thus 'free rides' on the cartel; the same result was obtained, for example, by Salant and others.

It would appear then that Saskatchewan producers have no incentive to form a cartel based on our static model. However, in a dynamic context, Nash cartel behaviour may become more plausible. Suppose the ore reserves of the ROW producers are small. In practice, the New Mexico firms for example have expected reserves which may last only another decade. Under a Nash cartel the ROW producers would exhaust these reserves more quickly than in the pure Nash equilibrium. When their reserves are depleted, the partial cartel becomes a monopoly unconstrained by the presence of nonmember producers.

We do not want to overemphasize the relevance of this case. Although reserves of many ROW producers are not large, a substantial share of the North American market could be supplied by a number of non-Saskatchewan producers who are either currently in the industry or potential entrants (under higher potash prices). While it is unlikely that these ROW producers would replace Saskatchewan producers, they could constrain monopoly behaviour and reduce the expected present value of profits from a Nash cartel. We thus conclude that the gains to a Nash or Stackelberg cartel are likely to be negligible.

4. SASKATCHEWAN POTASH PRODUCTION 1975-80

Having outlined what we feel are plausible strategies for a dominant firm owned by the government, we now consider which case is most consistent with PCS's behaviour since its inception. Ideally, we would like to examine their actions using a more realistic model which simulates equilibria using the industry's actual cost and demand conditions. We hope to pursue this approach if we obtain the firm-specific data required. Without the detailed simulation, we can nonetheless derive a tentative assessment of PCS's behaviour using our model and aggregate data. Table 2 summarizes the pertinent variables obtained under the different equilibria.

The 'test' we perform is the following. First we assume that, prior to the creation of PCS, the North American potash industry was an uncoordinated oligopoly, setting output as characterized by the Nash equilibrium. As noted earlier, this assumption seems quite plausible for the early 1970s. We then see if the creation of PCS leads to a new equilibrium solution.[19] That is, with PCS controlling a major share of the industry's productive capacity and reserves, does it use this potential dominance to obtain a different equilibrium? We will get an indication if PCS deviates from the non-cooperative Nash behaviour to the pure Stackelberg or the Nash cartel by looking at the market share of Saskatchewan producers before and after PCS was formed. We will not be able to distinguish between the pure Nash, joint-profit Stackelberg with $\gamma = 1$, and Stackelberg cartel, because, as explained, all lead to the same (or very similar) equilibrium outputs and hence market shares.

We use market share as an indicator of the equilibrium concept, because it is less sensitive than actual output to changes in exogenous variables such as shifts in potash demand. Due to confidentiality restrictions, we cannot obtain data for individual firms' (and mines') output and sales, so must base our evaluation on total Saskatchewan sales in North America. However, even with total Saskatchewan market share (PCS plus S), we can tell if there is a significant deviation from the Nash equilibrium. If we observe an increase in Saskatchewan's market share once PCS enters, it suggests a movement toward the Stackelberg or joint-profit Stackelberg equilibrium with γ very low. If we observe a declining market share for Saskatchewan, a shift toward the Nash cartel

---

19. Recall that there is no change in the number of firms operating in the industry after PCS is formed. PCS simply purchased existing mines. We are thus not looking for a comparative static effect within a given equilibrium concept, but whether the concept itself must change to reflect different behaviour.

TABLE 2

OLIGOPOLISTIC EQUILIBRIA

Variables	Nash, Stackelberg Joint-Profit (γ=1) and Stackelberg Cartel	Stackelberg	Stackelberg Joint-Profit (γ= .5)	Nash Cartel
q_g	$\frac{1}{2}(a+c)$	$(a+c)$	$\frac{4}{5}(a+c)$	$\frac{1}{3}(a+c)$
q_s	$\frac{1}{2}(a+c)$	$\frac{1}{3}(a+c)$	$\frac{1}{3}(a+c)$	$\frac{1}{3}(a+c)$
q_r	$\frac{1}{2}a - \frac{3}{2}c$	$\frac{1}{3}a - \frac{5}{3}c$	$\frac{2}{3}a - \frac{8}{5}c$	$\frac{2}{3}a - \frac{4}{3}c$
Q	$\frac{3}{2}a - \frac{1}{2}c$	$\frac{5}{3}a - \frac{1}{3}c$	$\frac{8}{5}a - \frac{2}{5}c$	$\frac{4}{3}a - \frac{2}{3}c$
P	$\frac{1}{4}(a+c)$	$\frac{1}{6}(a+c)$	$\frac{1}{5}(a+c)$	$\frac{1}{3}(a+c)$
Πg	$\frac{1}{8}(a+c)^2$	$\frac{1}{6}(a+c)^2$	$\frac{4}{25}(a+c)^2$	$\frac{1}{9}(a+c)^2$
Πs	$\frac{1}{8}(a+c)^2$	$\frac{1}{18}(a+c)^2$	$\frac{2}{25}(a+c)^2$	$\frac{1}{9}(a+c)^2$
Market Shares				
PCS	$\frac{a+c}{3a-c}$	$\frac{3(a+c)}{5a-c}$	$\frac{2(a+c)}{4a-c}$	$\frac{\frac{1}{2}(a+c)}{2a-c}$
S	$\frac{a+c}{3a-c}$	$\frac{a+c}{5a-c}$	$\frac{a+c}{4a-c}$	$\frac{\frac{1}{2}(a+c)}{2a-c}$
ROW	$\frac{a-3c}{3a-c}$	$\frac{a-5c}{5a-c}$	$\frac{a-4c}{4a-c}$	$\frac{a-2c}{2a-c}$

(cooperative) equilibrium may be indicated. No change in market share implies that the Nash or equivalent equilibria remain.

We calculate market shares of Saskatchewan producers over the period 1975-80, after prorationing was removed. Although PCS was set up in 1975, no PCS control over output from mines it acquired would have occurred until at least 1978. Therefore, we divide the period into pre-PCS control from 1975-77 and PCS-control (over four mines) from 1978-80. Our findings are presented in table 3.

TABLE 3
MARKET SHARE OF SASKATCHEWAN PRODUCERS, 1975-80

	1975	1976	1977	1978	1979	1980
Market Share[a]	71.3	74.7	70.9	73.6	72.5	72.3
Mean[b]		72.3			72.8	
Variance[b]		2.9			0.33	

Source of sales data: U.S. Bureau of Mines, Minerals Yearbook, selected years.

[a] Market share is the ratio of total Saskatchewan potash sales in Canada and the United States to total North American purchases of potash (in K_2O equivalent units of muriate of potash). Purchases of potash in Canada represent a very small fraction of the total market (less than 5 percent).

[b] For the periods 1975-77 and 1978-80 respectively.

The results are quite interesting. As can be seen, there is no significant deviation in market shares between the period 1975-77 and 1978-80. The mean of each period is approximately the same and the variance in output in the post-PCS period has greatly diminished. Our time period admittedly is quite small, but these figures suggest that PCS has not significantly deviated in its output strategy from the non-cooperative Nash equilibrium (or the equivalent equilibria summarized in table 2). We cannot tell if the equilibrium is pure Nash, or if PCS is behaving as a Stackelberg leader but maximizing jointly its own profits as well as those of the private sector firms in Saskatchewan. The important point however is that, over the period examined, there is no evidence of either collusive behaviour among Saskatchewan producers or pure Stackelberg leadership by PCS.

We have, however, some caveats to these results which may indicate a greater likelihood of Stackelberg behaviour by PCS in the future. We

make three observations. First, in the recent downturn in potash markets, PCS may have decreased its output more than the private sector in Saskatchewan.[20] An adverse demand shift can be reflected in our model by a decrease in the parameter a. Referring back to table 2, if a declines, PCS will decrease its output by more than the S producers only under the Stackelberg and joint-profit ($\gamma < 1$) Stackelberg cases. Obviously, factors not captured by our model could also explain the relative output decline for PCS.

Secondly, as noted in chapter 2, PCS embarked on a major expansion of its productive capacity in the late 1970s and early 1980s.[21] We have no capacity (investment) decision in our model, so our comments here are speculative. An increase in productive capacity could however indicate a desire by PCS to take a more dominant role in potash markets over time. The greater its productive capacity, the more influence PCS can have on market equilibria. These moves could be interpreted as preemptive strategies, preparing PCS to take a large market share as demand increases over time.

Finally, there are many legal and political factors which may be constraining PCS, preventing it from exerting any Stackelberg leadership at the present. These constraints may diminish over time. Recall the predictions of the Stackelberg (or Stackelberg joint-profit with $\gamma < 1$) case. PCS output will rise, S and ROW output and the price will fall (see table 2). Some of these ROW producers are from New Mexico and some of the S producers are owned by U.S. firms. Canadian actions which threaten the profitability of U.S. firms are not only politically unpopular in the United States but may lead to legal retaliation such as increased trade barriers. PCS might then risk a significant reduction in its sales by trying to act like a Stackelberg leader.

Suppose however that the New Mexico producers were to exhaust their reserves and there was no domestic production of potash in the United States. Then, vested interests might change because protection is no longer an issue. U.S. consumers of potash presumably prefer lower as opposed to higher prices and have no incentive to interfere with PCS actions. The adverse effects of the Stackelberg equilibrium on the

---

20. Our source for this information is the Globe and Mail, March 5, 1983. We have not been able to verify the information and do not want to overemphasize its importance.
21. With the recent change in government in Saskatchewan, all planned increases in capacity were halted in 1982. At this time, it is not clear what the new government intends for PCS. (Our conversation with a PCS manager suggests that PCS too is uncertain about the provincial government's plans for its Crown corporation.)

private sector producers in Saskatchewan would remain. Their output, market share, and profits would decline compared to the Nash case. They might thus have a strong incentive to seek a cooperative arrangement with PCS. The most likely cooperative equilibrium in such a case is the Stackelberg cartel. The Nash cartel is unlikely because of legal and political issues. For example, the Nash cartel raises potash prices, and without the New Mexico producers to benefit from these higher prices, U.S. potash consumers may sway political opinion. Because some of the private sector producers in Saskatchewan are U.S. subsidiaries, antitrust litigation becomes a possibility.[22] The Stackelberg cartel would likely escape this litigation because there would be little observable differences between it and the non-cooperative oligopolistic equilibrium.

Thus, we have come back full circle to the Nash solution as the most plausible oligopolistic equilibrium. In our model, a government-managed firm which has a large share of the productive capacity of the industry appears to have very little potential or incentive to deviate from the Nash solution. Even if the government pursues objectives different from those of private-sector firms (for example, the Stackelberg joint-profit equilibrium), it's output level and thus those of the other firms will be identical or very close to that achieved in the Nash case. Similarly, the government and private-sector firms have very little incentive to form any sort of cartel, not only because of legal and political difficulties but because their profits either remain constant or fall, at least in the short term.

22. The precedent for anti-trust litigation is the U.S. case against Saskatchewan uranium producers in the 1970s.

5. CONCLUSIONS AND IMPLICATIONS FOR THE CANADIAN ECONOMIC UNION

Our results suggest that a provincial Crown corporation, established to extract a share of the resource rents and to stabilize an industry, may behave in a way no different from private-sector firms operating in the same industry even if its objective function differs from those of private-sector firms. The effect on the Canadian economic union is negligible, except that the share of the rents going to the provincial government will increase relative to the pre-PCS environment. In the case of potash, some of these increased rents will come from the federal government due to the federally tax-exempt status of Crown corporations. Thus some redistribution of tax revenue will occur. The other source of the province's rents are the private-sector firms which were purchased by PCS. As some of these firms were foreign owned, their takeover may represent an increase in the total rents remaining in Canada rather than simply a redistribution of rents from the federal to provincial government.

In some respects, PCS is yet another manifestation of the increasing provincial control over production and trade in Canada. However, there are some important distinctions between PCS and other examples of government firms and their control over resources (e.g. the Heritage Fund in Alberta, or provincial oil and gas firms). First, approximately 95 percent of Saskatchewan potash is exported. Any provincial policies affecting potash production and prices will have minimal effects on Canadian consumers. Secondly, as this paper has shown, provincial ownership of over 40 percent of potash capacity does not mean it will behave any differently than the private sector firms it acquired nor the firms with which it currently competes. Government firms which take over private sector activities but are still constrained by international markets may have no effect on the existing allocation of resources. Finally, the constitution and the federal-provincial conflicts in the early and mid-1970s over resource ownership and rights to resource rents largely created PCS. The existence of PCS does not change the nature of the conflict or disrupt an economic union that was not already shaky.

BIBLIOGRAPHY

David L. Anderson, The Role of Mineral Taxation in Industry-Government Conflict, (Kingston: Centre for Resource Studies, 1981).

G.S. Barry, 'Potash', Canadian Mining Journal, February 1982, pp. 128-130.

Economic Council of Canada, Financing Confederation, Ottawa, 1982.

Energy, Mines and Resources, Potash, MR156, Ottawa, 1976.

A.F. Killin, 'Potash', Canadian Mining Journal, 1977, pp. 70-71.

J.K. Laux and M.A. Molot, 'The Potash Corporation of Saskatchewan' in A. Tupper and G.B. Doern (eds.) Public Corporations and Public Policy in Canada, (Montreal: The Institute for Research on Public Policy, 1981).

T.R. Lewis, and R. Schmalensee, 'On Oligopolistic Markets for Nonrenewable Resources', Quarterly Journal of Economics, XCV, 1980, pp. 475-491.

W.D. Moull, 'Natural Resources: The Other Crisis in Canadian Federalism', Osgood Hall Law Journal, 18, 1980, pp. 2-48.

W.D. Moull, 'Section 92A of the Constitution Act, 1867 - Some Thoughts and Reflections', 1982.

R.S. Pindyck, 'Gains to Producers from the Cartelization of Exhaustible Resources', Review of Economics and Statistics, 60, 1978, pp. 238-251.

J. Richards, and L. Pratt, Prairie Capitalism: Power and Influence in the New West, (Toronto: McClelland and Stewart, 1979).

S.W. Salant, 'Exhaustible Resources and Industrial Structure: A Nash-Cournot Approach to the World Oil Market', Journal of Political Economy, 84, 1976, pp. 1079-1093.

United States Bureau of Mines, Minerals Yearbook, selected years.

United States Bureau of Mines, Mineral Facts and Problems, 1980.

J.D. Whyte, 'A Constitutional Perspective on Federal-Provincial Sharing of Revenues from Natural Resources' in C.E. McLure, Jr. and P. Mieszkowski (eds.) Fiscal Federalism and the Taxation of Natural Resources, (Lexington, Mass.: D.C. Heath & Co., 1983).

THE AUTHORS

Frank Robert Flatters is a graduate of Carleton University, with a B.A. (Hons.) in economics. He also received an M.A. in economics from the University of Western Ontario, and a Ph.D. in economics from The Johns Hopkins University. Dr. Flatters has taught at The Johns Hopkins University, the University of Chicago and Queen's University, where he is Associate Professor in the Department of Economics. The author of many publications, his research interests include international economics, the problems of allocation of resources in a federal system, and natural resource revenues.

Nancy D. Olewiler has a B.A. (Hons.) from Barnard College at Columbia University, an M.A. from Simon Fraser University, and a Ph.D. from the University of British Columbia, all in economics. Dr. Olewiler has worked in economic research for the State of New York and the First Boston Corporation, and taught at Michigan State University and the University of British Columbia. She is presently Assistant Professor of economics at Queen's University, where her research interests lie in the areas of econometrics and resource economics.

THE CENTRE FOR RESOURCE STUDIES

The Centre for Resource Studies (CRS) was established in 1973, under the sponsorship of Queen's University, the federal Department of Energy, Mines and Resources, and The Mining Association of Canada, to carry out a program of research and publication on mineral policy issues.

The Centre provides opportunities for multidisciplinary research in resource studies at Canadian universities, furnishes reliable information on matters related to mineral resource policy, and promotes closer liaison between government, industry and other concerned groups. The research program is carried out both at the Centre and by means of contracts with qualified investigators, usually at Canadian universities. Small exploratory studies are also funded, through a system of grants-in-aid of research. CRS Seminars involve representatives from governments, industry, universities, labour, and other interested groups in working sessions on issues of current concern. Through this program of research and seminars, and the resulting publications, the Centre contributes to informed discussions and a better understanding of significant issues.

The Centre is governed by a board of directors which establishes general policy and priorities for research. The board has sixteen members, appointed by Queen's University, The Mining Association of Canada, and the federal government. Guidance on the research program, together with discussion of policy issues and other matters, is provided by the Advisory Council. This body comprises all researchers associated with the Centre, together with members appointed from such groups as governments, industry, labour, and other interests. A Research Advisory Committee aids in the development of projects and the selection of research proposals. The executive director and staff are responsible for the work of the Centre within this framework.

Most of the funding for the Centre's activities is provided by the sponsors. In addition, the Centre accepts contracts from other organizations interested in mineral policy research.

The Centre welcomes comments on its publications, proposals for research projects or for publication, or enquiries about any aspect of its work. For further information, contact:

Executive Director,
Centre for Resource Studies
Queen's University
Kingston, Ontario, Canada K7L 3N6
(613) 547-5957

CRS PUBLICATIONS

Monographs (Paperback)

Conflict and its Resolution in the Administration of Mineral Resources in Canada, by R.M. Burns; 62 pages, 11 tables. Published 1976.

The Impact of the Mining Industries on the Canadian Economy, by R.W. Boadway and J.M. Treddenick; 116 pages, 15 tables. Published 1977.

The Transportation Impact of the Canadian Mining Industry, by A.I. Wallace; 154 pages, 17 tables. Published 1977.

Human Resources in Canadian Mining: A Preliminary Analysis, by J.A. MacMillan, G.S. Gislason, and S. Lyon; 174 pages, 48 tables. Published 1977.

Health and Safety in the Canadian Mining Industry, by G.W. Gibbs and P. Pintus; 248 pages, 58 tables. Published 1978.

The Canadian Nonferrous Metals Industry: An Industrial Organization Study, by E. Urquhart; 158 pages, 18 tables. Published 1978.

Economic Impacts and Linkages of the Canadian Mining Industry, by P.E. Nickel et al., 140 pages, 31 tables. Published 1978.

Environmental Impact of Mining in Canada, by E.A. Ripley et al., 274 pages, 45 tables. Published 1978, reprinted 1982.

Effects of Taxation on Base Metal Mining in Canada, by B.W. Mackenzie and M.L. Bilodeau; 188 pages, 29 tables. Published 1979.

Gold: The World Industry and Canadian Corporate Strategy, by E. Cousineau and P.R. Richardson, 192 pages, 32 tables. Published 1980.

The Impact of Policy Change on Decisions in the Mineral Industry: The Case of Exploration in Manitoba, 1969-77, by B.E. Owen and W.J. Kops; 116 pages, 8 tables. Published 1980.

The Role of Mineral Taxation in Industry/Government Conflict: The Case of the Saskatchewan Potash Reserve Tax, by David L. Anderson; 135 pages, 41 tables, 2 illustrations. Published 1981.

Profitability in the Canadian Mineral Industry, by Charles H. Pye; 178 pages, 42 tables, 12 illustrations. Published 1981.

Proceedings

No. 1 Rate-of-Return Taxation of Minerals, with papers by B.W. Mackenzie and M.L. Bilodeau, P.M.T. White, N.D. Olewiler, J.T. Cawley, and E.P. Gush; 109 pages. Published 1978.

No. 2 International Competition and the Canadian Mineral Industries, with papers by H.C. Armstrong, H.T. Fargey, C.G. Miller, N.D. Olewiler and P.R. Richardson, D. Perlstein, and K.C. Hendrick; 109 pages. Published 1978.

No. 3 Current Concerns in Mineral Policy, with papers by C.R. Archibald, W.J. Barbour, D.B. Brooks, J.S. Dowsett, J.M. Fleming, and G.A. Jewett; 75 pages. Published 1978.

No. 4 Canada's Mineral Trade: Implications for the Balance of Payments and Economic Development, with papers by B.W. Wilkinson, D.J. McCulla, J.G. MacKinnon, A.G. Balogh, and W.G. Chambers and J.S. Reid; 113 pages. Published 1978.

No. 5 Employee Relations Initiatives in Canadian Mining, with papers by W.J. Bennett, F.R. Nogas and J.P. Fulcher, W.F. Clarke, S.B. Jones, T.F. Cawsey and P.R. Richardson, and P. Warrian; 85 pages. Published 1979.

No. 6. Junior Mining in Canada: The Problem of Investment and Securing Fair Returns, with papers by A.J. Freyman, B.A. Kalymon, J.D. Mason, D.W. Scrim, E.H. Neave and P.R. Richardson, and E.G. Thompson; 101 pages. Published 1979.

No. 7 The Future for Junior Mining in Canada, with papers by Hon. J.A.C. Auld, J.L.C. Lyndon, N.B. Keevil Jr., D.G.C. Menzel, H.T. Fargey, A.J. Freyman, Hon. R. Hnatyshyn, J.C. Baillie, D.W. Scrim, J.P. Bunting, E.H. Neave and P.R. Richardson, L.A. English, M. St-B Harrison, R.H. Grasley, and Hon. F. Drea; 125 pages. Published 1979.

No. 8 Mining-Linked Diversification of the Sudbury Basin Economy, with papers by D.C. Frith, J.P. Reny, A.I. Wallace, J.H. Holtby and L.C. Kitchener, 53 pages. Published 1980.

No. 9 The Changing Structure of the Canadian Mineral Industry, with papers by I.A. Stewart, R.F. Mikesell, R. Simeon, R. Keyes and J.M. MacLeod; 105 pages. Published 1980.

No. 10 Northern Mining in the 80s, with papers by Hon. G. Braden, R.J. Cathro, D. MacKinnon, J. Smith, R.W. Stephenson, B.E. Novak, E.N. Doyle, J.R. Witty, J.E. Marshall, A.G. Gordon, J. McCormack, H.B. Hicks, J. Zigarlick, T. Shearcroft, W. Kupsch, J. Stabler, and Hon. J. Erola, 110 pages. Published 1980.

No. 11 Skilled Manpower Shortages in the 1980s: Towards a Cooperative Solution, with papers by R.J. Gray, J.S. Reid, W.H. Digby, J.B. Hopkinson, A. Knoll, O. Tremblay, G. Betcherman, P.E. Womersley, M.J. Alton, V.C. Allman, C. Stairs, E.J. Weiss, and W.E. McBride; 116 pages. Published 1981.

No. 12 Acid Rain Controls and the Economics of the Canadian Nonferrous Mineral Industry, with papers by J. Gerin, W.G. Deeks, P.R. Clarke, J.B. Hyne, H.T. Fargey, B.W. Mackenzie, and E.J. Ward; 90 pages. Published 1982.

No. 13 Mineral Policy Formulation: The Role of Scientific and Technical Knowledge, with papers by G.A. Jewett, H.D. Drechsler, P.G. Halkett, D.E. Bond, D.C. Findlay, W.G. Jeffery, L.G. Bonar, D.W. Davis, and J. Zwartendyk; 135 pages. Published 1982.

Working Papers

No. 3 Provincial Mineral Policies: Newfoundland, 1949-75, by M.J. Prince, 67 pages, 7 tables. Published 1977.

No. 6 Provincial Mineral Policies: Saskatchewan, 1945-75, by R.C. Murray; 64 pages. Published 1978.

No. 8 Federal Mineral Policies: 1945-75, by M.J. Wojciechowski; 85 pages, 21 tables. Published 1979.

No. 9 Trends in Canada's Mineral Trade, by B.W. Wilkinson, 63 pages, 27 tables. Published 1978.

No. 10 Canada as a World Zinc Producer: Prospects to 1980, by N.D. Olewiler, P.R. Richardson, and L. Rumble, 22 pages, 12 tables. Published 1978.

No. 11 A Survey of Resources and a Production Cycle for the Nonferrous Metals, by C. Lafkas and J.G. Paterson, 34 pages, 9 tables. Published 1978.

No. 12 Solar Energy and the Canadian Mining Sector: A Demand Forecast, by J.S. Shewchun and D.B. Curtis; 45 pages, 14 tables. Published 1978.

No. 13 Cerro Colorado: A Case Study of the Role of Canadian Crown Corporations in Foreign Mineral Development, by C.G. Miller, N.D. Olewiler, and P.R. Richardson; 44 pages, 5 tables. Published 1979.

No. 14 The Administration of Mineral Exploration in the Yukon and Northwest Territories, by K.A. Graham, R.G. McEachern and C.G. Miller; 42 pages. Published 1979.

No. 15 Public Policy Aspects of Information Exchange in Canadian Mineral Exploration, by D.O.Downing and B.W. Mackenzie, 52 pages. Published 1979.

No. 16 Canada's Competitive Position in Copper and Zinc Markets, by B.W. Mackenzie; 41 pages, 21 tables. Published 1979.

No. 17 Constitutional Change and the Mineral Industry in Canada, by Wendy MacDonald; 66 pages. Published 1979.

No. 18 An Economic Analysis of the Canadian Taxation of an Integrated Mining Company, by Jean-Thomas Bernard; 112 pages. Published 1980.

No. 19 Looking for the Improbable Needle in a Haystack: The Economics of Base Metal Exploration in Canada, by B.W. Mackenzie, 48 pages. Published 1980.

No. 20 The Market Price of Risk in the Canadian Mining Industry, by H.F. Campbell, 29 pages. Published 1980.

No. 21 Public Affairs and the Minerals Industry: Junior Mining; Northern Development; Loans for Foreign Mines; A Public Relations Strategy, by C.G. Miller; 42 pages. Published 1980.

No. 22 Newfoundland Mining Industry: Present Status and Potential for Expansion, by N.D. Olewiler and C.H. Pye; 208 pages, 83 tables. Published 1980.

No. 23 Effects of Water Pollution Control Costs on Base Metal Mining in Canada, by N.A. Papanicolaou and B.W. Mackenzie; 74 pages. Published 1981.

No. 24 The Costs of Uncertainty: Regulating Health and Safety in the Canadian Uranium Industry, by I. Robinson; 74 pages, 3 illustrations. Published 1982.

No. 25 Economic Guidelines for Small Mineral Deposits/Directives economiques relatives aux petits gisements, by B.W. Mackenzie and M.L. Bilodeau; 66 pages, 12 tables, 14 illustrations. Published 1982.

No. 26 Effects of Public Policy on Investment Demand: The Case of Taxation in Canadian Base Metal Mining, by B.W. Mackenzie and C.H. Pye; 58 pages, 17 tables, 11 illustrations. Published 1982.

No. 27 The Prospects for Canadian Uranium, by S. Salaff; 50 pages, 9 tables. Published 1983.

No. 28 Economic Mineral Exploration Targets, by B.W. Mackenzie; 72 pages, 3 tables, 19 illustrations. Published 1984.

No. 29 Dominant Government Firms in an Oligopolistic Industry: The Case of Saskatchewan Potash, by F. Flatters and N. Olewiler; 43 pages, 3 tables. Published 1984.

Technical Papers

No. 1 Financing and Stabilization Policies in a Cyclical Industry: The Case of Inco in the Seventies, by W.T. Cannon; 200 pages, 33 tables, 12 illustrations. Published 1981.

No. 2 Economic Effects of Smelter Controls on the Canadian Nonferrous Mining Industry, by B.W. Mackenzie and M.L. Bilodeau; 162 pages, 44 tables, 16 illustrations. Published 1982.

No. 3 Secondary Supply of Copper and Ferrous Metals and Canadian Metal Markets, by K. Stollery; 138 pages, 24 tables, 16 illustrations. Published 1983.

Mineral Policy Updates

Mineral Policy Update 1981, by Margot J. Wojciechowski and C.E. McMurray; 85 pages. Published 1983.

Mineral Policy Update 1982, by Margot J. Wojciechowski and C.E. McMurray; 88 pages. Published 1983.

Eastern Arctic Study
(Published jointly by the Centre for Resource Studies and the Institute of Local Government)

The Inuit Land Claim, Constitutional Development, and Local Government Reform in the Northwest Territories: An Overview, by Katherine A. Graham and Anne B. McAllister, 50 pages, published 1981.

Industrial Development in the Eastern Arctic Study Area: A Preliminary Overview, by C. George Miller, 31 pages, published 1981.

Eastern Arctic Study Bibliography Listings, as of June 1, 1981, by M.P. Sharon Brown, 70 pages, published 1981.

Eastern Arctic Study Case Study Series: The Alaska Native Claims Settlement, by David Baker, 100 pages, published 1982.

Eastern Arctic Study Case Study Series: Mineral Exploration in the Baker Lake Area, by Anne B. McAllister, 58 pages, published 1982.

Eastern Arctic Study Case Study Series: The Development of the Polaris Mine, by Katherine A. Graham, 61 pages, published 1982.

Eastern Arctic Study Case Study Series: The Nanisivik Mine, by Margot J. Wojciechowski, 62 pages, published 1982.

POOR

QUALITY

ORIGINAL